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In Search of a Causal Relationship Between Industrial Output and Employment in Ireland

JOHN P.C. FELL*
Central Bank of Ireland

I INTRODUCTION

Recently, many analysts of the Irish Manufacturing sector have been concerned with an apparent negative relationship, between aggregate industrial employment and output in Ireland, that has developed since 1980. Over the period 1980 to 1987, industrial output increased by almost 50 per cent while industrial employment declined by about 20 per cent over the same period. This experience contrasts sharply with the period 1976 to 1980 when industrial output rose by 24 per cent and employment rose by 10 per cent. An explanation often implied for this apparent negative relation is the composition of aggregate industrial output between "Modern" and "Traditional" sectors (see Baker (1988)). From a constructed index for the Modern high-technology export-oriented sector Baker illustrates that output over the period 1980-87 expanded by 180 per cent in the sector while employment expanded by 22 per cent. The typical explanation for the growth in labour productivity in these sectors is the capital intensive nature of the production

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processes. However, in the "Traditional" sector output expanded by 2 per cent over the period 1980-87 while employment declined by 27 per cent. The typical explanation for this experience is the negative impact of rising real wages and the consequent loss in competitiveness on a labour-intensive production process.

Much anecdotal type argument has been put forward to explain the decline in employment in the manufacturing sector as Massey (1988) has noted. Massey has argued that the decline in manufacturing employment may have been due to a number of factors other than competitiveness. He notes that external shocks due to higher energy costs, technical change and increased competition from the Newly Industrialising Countries and increased competition since EC entry may have had a negative influence on manufacturing employment. Also, the restrictive fiscal stance of the 1980s and its impact on both domestic demand and the supply side of the economy may have had an adverse influence.

The present paper is not concerned with these external influences but concentrates itself on the relationship between the labour input and output in the manufacturing industry. In particular, this paper attempts to determine whether there is a direct causal relationship between the labour input and output while recognising that the existence of other external factors such as non-wage labour costs, energy, materials and capital costs may have a dampening influence on this relationship. For example, Kirwan (1977) found that non-wage labour costs had a dampening but small influence on the relationship between Irish manufacturing output and employment.

A study by Sims (1974) attempted to determine the existence of a causal relationship between US industrial output and employment and was a similar study in many ways to the present study. Sims found causality in both directions between output and employment for the US data using the Sims (1972) causality testing procedure. In the Sims (1974) paper it is argued that most previous studies had estimated single-equation distributed lag regressions which treated labour input as the dependent variable. This seems to have been because of a prior assumption that output changes are causally prior to employment changes. Sims claims that using the Sims causality testing procedure, which includes both labour input and output as dependent variables, and by only making weak hypothesis of the forms of estimated lag distributions estimates of the labour input-output relation should be sharpened. The present paper follows Sims' advice by using a similar econometric methodology; the Vector Autoregression (VAR) approach. This technique is similar in that it makes no prior assumption about the causal priority between labour input and output as it also allows both labour input and output to be included as dependent variables.

Sims used two sets of bivariate tests to determine whether a causal relationship existed between labour input and output. The first set of tests involved output and manhours while the second set involved output and employment. The present paper uses tests involving four variables: output, employment, hours worked and real wages. The explanation for including employment and hours worked separately were twofold. First, it seemed appropriate to include both measures of the labour input especially as hours worked are often used to fill the "gap" when there is excess demand for workers (see Kirwan, 1977). Secondly, both variables were included separately primarily because including manhours alone implies that coefficients on both employment and hours are identical which may not be the case especially if overtime hours are more expensive than standard hours. The inclusion of both variables separately may capture any substitution that takes place between employment and hours and also any indirect interactions with output. The real wage was included as a variable that is expected to have an influence on employment and to determine whether rising real wages have had an adverse influence on employment and output in the manufacturing sector. Vector Autoregressions using these four variables are estimated for both aggregate and disaggregated data on the industrial sector.

The plan of this paper is as follows. In Section II a brief description of the Model and the Vector-Autoregression (VAR) methodology is presented. In Section III there is a discussion on lag-length selection in the VAR. In Section IV an outline of data availability and sources is provided. In Section V an outline of the causality test results is provided. Finally, in Section VI, a summary and some concluding remarks are presented.

II THE MODEL

In Granger's (1969) sense, a time series $\{X_t\}$ is said to cause another time series $\{Y_t\}$ if forecasts of future Y can be improved using past X given present and past Y. He suggests a direct method of determining whether a causal relationship exists between variables. This involves regressing X on its own past and that of Y which is essentially the employment of a Vector Autoregression (VAR), the properties of which were later investigated by Sims (1980). The possibility that Y causes X can be examined directly by testing whether the coefficients of lagged Y are zero. This technique is useful for the present purpose as it allows us to investigate whether the perverse negative relationship that has apparently developed between aggregate industrial output and employment is coincidence. The present VAR model consists of four variables: output, employment, hours worked and the real (inclusive of PRSI) wage paid by employers. By testing each of the dependent variables in the VAR system, the importance of the labour input in the Irish production process can be determined. It can also be determined whether the increase in real wages in the industrial sector has had an adverse impact on employment and output.

The following VAR model was initially suggested to represent the multivariate process (Q_t, E_t, H_t, W_t)

$$A(L)Y_t = U_t \tag{1}$$

$$\begin{aligned} \text{with } A(L) &= I - A_1 L - A_2 L^2 - \ldots - ApL^p \\ E(U_T) &= 0, \ E(U_t U_t^1) = \Sigma \\ E(U_t U_s^1) &= 0, \ t \neq s, \ E(\acute{Y}_t U_s^1) = 0 \quad t < s \\ Y_t &= (Q_t, E_t, H_t, W_t) \end{aligned}$$

where Y is an (n×1) vector of variables, A is an (n×n) matrix of coefficients, U is an (n×1) vector of white noise disturbance terms and L denotes the lag operator. The variables which appear in the Y vector are gross output (Q), numbers employed (E), hours worked (H) and real wages (W). It became apparent that all of the series exhibited significant seasonality and that a trend variable was also required in a number of the equations. In order to avoid a common deterministic seasonal or trend component between two or more variables being mistaken as Granger-Causality it appeared appropriate to include deterministic trend and seasonal variables in the VAR model. An intercept term was also included in the model and all variables were logged in an effort to stabilise the variance. An advantage of logging the variables is that the elasticities are yielded directly. The final specification of each of the equations in each of the VAR systems may be written in log-linear form as

$$Y_t = \alpha + \beta T + \sum_{i=1}^{3} \gamma_i S_i + \sum_{p=1}^{n} \sigma_p Q_{t-p} + \sum_{i=1}^{n} \lambda_p E_{t-p} + \sum_{p=1}^{n} \phi_p H_{t-p}$$

$$+ \sum_{p=1}^{n} \psi_p W_{t-p} + \Sigma_t \tag{2}$$

where the vector Y is the log of the vector defined earlier. Each variable is assumed to be a log-linear function of its own lagged values, the lagged values of each other variables; a time trend; the season and a white noise error term or linearly unpredictable "innovation". The lag lengths (p) in the VAR system (2) are restricted to be equal for all variables in the system.

A convenient feature of the VAR model (2) is that once p is chosen, the p-th order VAR may be estimated by ordinary least squares which will yield consistent and asymtotically efficient estimates of the coefficients in each of the equations. As the right-hand side variables in (2) are either deterministic or past values of the elements in the Y vector, they are all predetermined. Therefore, the system (2) can be consistently estimated using OLS without being concerned about the existence of simultaneous equations bias. Also, estimating each equation separately using OLS yields asymtotically efficient estimates because the right-hand side variables are the same in every equation.

It should be noted when examining the signs on some of the coefficients in (2) that as Zellner and Palm (1974) and Zellner (1979) have demonstrated any VAR system constitutes an unrestricted reduced form of some unknown underlying structural system of equations. Therefore, although the employment equation, for example, appears to constitute a conditional factor demand (which implicitly holds the cost of other factors constant), there is no reason to hold a prior expectation of a negative relationship between employment and the real wage. For example, suppose the real wage lies below the equilibrium level so that the demand for labour exceeds the supply and there is voluntary unemployment, a rise in the real wage should lead to an increase in employment. There are other interactions between variables such as output and employment through which we would expect unambiguous relationships but because we may be observing changes in both supply and demand in some of the interactions between variables it will not always be immediately obvious what the direction of the relationship will be.

III LAG-LENGTH SELECTION

Thornton and Batten (1985) demonstrated in their money and income study that the outcome of causality testing is quite sensitive to the choice of lag structure. Using different criterion for lag-length selection they found that the selection of different lag-structures can result in different interpretations of the causal relationship between variables. Bearing this problem in mind, five system tests were used in the present study to estimate the appropriate lag-length. Following Hakkio and Morris (1984) an initial maximum lag-length was set at 4 quarters in each VAR system primarily because of the scarcity of observations (as outlined in Section IV) and in order to avoid overfitting in the equations.

Following Hakkio and Morris, the first system test utilised to estimate the lag length was the likelihood ratio test. The likelihood ratio statistic for testing AR(m) against AR(l), $l < m$, is

$$\Lambda = (T - C)(\ln|\hat{\Sigma}_l| - \ln|\hat{\Sigma}_m|) \sim \chi^2(k^2(m - 1)) \qquad (3)$$

where k is the number of variables and C is a correction factor suggested by Sims (1980) to perform a degree of freedom correction to a χ^2 statistic, analogous to an F-statistic. The value of C equals the number of variables in each unrestricted equations of the VAR. The testing procedure using the likelihood ratio is to examine each restriction against all other possibilities. The lag-length which does not impose a restriction on all other lag-lengths is chosen.

The other four system tests used to determine the lag-length were information criterion tests outlined in Judge *et al.* (1985) given by

$$SC(j) = \ln|\hat{\Sigma}_j| + \frac{k^2 j \ln T}{T} \tag{4}$$

$$AIC(j) = \ln|\hat{\Sigma}_j| + \frac{2k^2 j}{T} \tag{5}$$

$$FPE(j) = \left(\frac{T+j}{T-j}\right)^k |\hat{\Sigma}_j| \tag{6}$$

$$HQ(j) = \ln|\hat{\Sigma}_j| + \frac{2jk^2 \ln\ln T}{T} \tag{7}$$

where (4) denotes Schwarz Criterion, (5) denotes Akaike Information Criterion, (6) denotes Akaike's Final Prediction Error Criterion and (7) denotes the Hannon-Quinn Criterion. Each of these criteria involve a trade-off between goodness of fit and parsimony analogous to an adjusted R^2 statistic. Also each provides an estimate of the lag-length according to the estimation rule that $\hat{P}$ is chosen such that

$$\psi(\hat{P}) = \min\{\psi(j)|j=1, \ldots, m\} \tag{8}$$

These criteria will not in general always choose the same lag length. Judge *et al.* (1985) mention that the SC and HQ criteria provide an asymtotically consistent estimate of P. However, the FPE and AIC criteria will asymtotically overestimate P with positive probability. The SC criterion in the present study tended to always choose a lag of 1 while the FPE tended to choose a lag of 4, while AIC and HQ almost always tended to be in agreement.

In the present study the first step in the lag-length selection procedure was to estimate an *initial* lag-length. This was performed by letting the majority rule, i.e., the five system tests discussed above were implemented and the lag-length which was chosen by the greatest number of tests was selected. In no case did five out of five tests choose the same lag-length because SC always chose lag 1 and FPE always chose lag 4. However, in a large number of cases four out of five tests chose the same lag.

Granger and Newbold (1974) have indicated that if substantial autocorrelation remains in the residuals of (2) above, although the least squares estimates will be consistent, bias will occur in the estimates of their variances. Very often this bias is downward resulting in inflated t- and F-statistics and R^2 values. Therefore if the lag-length chosen by the system tests leaves substantial serial correlation in the residuals, it is possible that causality may be believed to have been found where it does not exist. Therefore, it is imperative to remove autocorrelation in the initial estimated VAR systems.

The second step in the lag-length selection procedure was to test all of the initial equations in each of the VAR systems for autocorrelation using the Ljung-Box Q-statistic. If the initial lag-length demonstrated a lack of autocorrelation then it became the final chosen lag-length. However, if there appeared to be evidence of significant (above the 5 per cent level) autocorrelation in the initial system then it was eliminated from the ranking and the procedure reverted to step 1 without the *initial* specification until a lag-length which demonstrated no evidence of autocorrelation in any of the equations was identified. This should give the Granger-Causality F-tests a meaningful interpretation. This procedure proved fruitful in most cases. However, in a few cases autocorrelation remained in some of the equations after all lags were tested. In these cases the lag-lengths that minimised the autocorrelation problem were selected bearing in mind the Granger and Newbold criticism.

IV DATA AND ESTIMATION PERIODS

An impressive feature of the dataset available for the Irish Industrial sector is its comprehensiveness at detailed sectoral level. A regrettable feature, however, is the frequency and length of some of the available series. This places some limitations on degrees of freedom in time series work especially on Vector Autoregressions which often require a large number of coefficients to be estimated. None the less, the present study makes full use of all available data. The objective of the study is to determine the importance of the labour input in the Irish Industrial production process. This requires four consistent series at aggregated and disaggregated level on output, employment, hours worked and real wages paid by employers. The data availability and limitations are discussed below.

The present series available for the Irish Industrial sector is compiled under the NACE classification scheme and dates from 1973. Previously (i.e., between 1954 and 1973) statistics were compiled under the ISIC classification scheme and are not readily comparable with the NACE statistics so that detailed industry-level series of output, employment, hours and earnings are not comparable with the new series. As Kirwan and McGilvray (1983) explain, even at the aggregate level for all industries, there are differences in output and employment resulting from differences in coverage between the two systems.

Gross output series for the manufacturing sector are available monthly for

10 disaggregated groups at the NACE-2-digit level and for 30 disaggregated groups at the NACE-3-digit level. These series are available retrospectively to July 1975 for all but 6 of the NACE-3-digit categories where series are available from January 1980. Regrettably only quarterly series are available for employment, earnings and hours worked. A continuous series for these NACE categories is available retrospectively to Quarter-one 1977 except for the 6 categories which do not have output series prior to 1980 where employment data, etc., is available from Quarter-three 1979. One sector, Mineral Oil refining, does not have available data on employment, earnings or hours worked at all. For the aggregate manufacturing series output data are available monthly from July 1975 while the employment earnings and hours worked series are available from 1973, Quarter-three.

To construct real wage series at a disaggregated level it is necessary to deflate the weekly nominal wage series by the appropriate Wholesale Price Index. It is with the available Wholesale Price Indices where real data limitations exist. Wholesale price indices are available monthly retrospectively from January 1975 for only 21 out of the remaining 39 NACE disaggregated groupings for which full datasets exist otherwise. For the categories which do have Wholesale Price Indices 5 are at the NACE-2-digit level and 16 are at the NACE-3-digit level. Regrettably, Wholesale Price Indices for four out of the five sectors labelled by Baker (1988) as "Modern" high-technology sectors which have provoked a considerable amount of interest in recent years do not exist primarily because of the rapidly changing composition of their outputs. However, rather than deflate by inappropriate price indices or ignore these remaining 17 NACE groupings, it was decided to construct Wholesale Price Indices that would have as meaningful an interpretation as possible.

Wholesale Price Indices for these sectors may be constructed by making use of the implicit relationship between the industrial turnover and gross output indices. Kirwan and McGilvray (1983) note that the volume of gross output series constructed by the CSO is essentially the sum of three components: turnover, net change in stocks and work in progress, i.e.,

$$Q = T + \Delta S + \Delta q \qquad \text{(a)}$$

The value of industrial turnover indices are published monthly and extend back to January 1980. These indices are available for all but one of the sectors (manufacture of other means of transport) which do not have Wholesale Price Indices. Now if it is assumed that these three components are valued at the same price on a monthly basis, we can write,

$$PQ = PT + P\Delta S + P\Delta q \qquad \text{(b)}$$

where P denotes the Wholesale Price Index. Therefore, the wholesale price can be found by dividing across by Q, i.e.,

$$P = P(\frac{T}{Q}) + P(\frac{\Delta S}{Q} + \frac{\Delta q}{Q}) \qquad (c)$$

However, we only have monthly observations for Q and PT to track movements in the WPI. So, to arrive at a perfect estimate of the Wholesale Price Index it must be true that $d\hat{P} = d\,P(\frac{T}{Q})$. In the absence of significant stock revaluation effects over a month, this essentially requires the share of turnover in output to remain constant. If $(\frac{T}{Q})$ remains constant, then movements in the WPI will be tracked perfectly. However, if $(\frac{T}{Q})$ is moving as well as P, then the movements in $(\frac{T}{Q})$ will appear as movements in the WPI and it will not be tracked perfectly.

It cannot be expected that $(\frac{T}{Q})$ will remain constant for two main reasons: stocks and work in progress. The share of the change in stocks in output cannot remain constant in the long-run as this would imply a build-up in stocks towards infinity. Also, work in progress may create differing seasonal patterns in T and Q. This is because work in progress in period 1 may be sold in period 2 so that deflating period 2 turnover by period 2 output may not give the correct price index. It was found in the trial construction of these indices that for sectors which did have a WPI, the constructed indices appeared to exhibit significantly stronger seasonality, while the actual indices appeared to be very smooth. Therefore, the seasonality in all of the constructed indices was dampened by applying a four-quarter moving average. It was found that for sectors which did have WPIs, the fit of the constructed (with moving average) WPI on the actual WPIs was better than the constructed WPIs without the moving average.

The final series to construct was the real wage paid by the employer. This was achieved by "adding on" the average quarterly PRSI payment estimates of Hughes (1985) onto the nominal wage rates of each sector along with updates from the Reports of the Department of Social Welfare. The resulting nominal wages paid by employers were then deflated by the constructed or actual Wholesale Price Indices. All of this left three estimation periods for the available consistent quarterly data. The longest estimation period was for the aggregate data which was estimated over the period 1975 Q3 to 1988 Q3. For 21 NACE groups (5 at 2-digit level and 16 at 3-digit level) an estimation period from 1977 Q1 to 1988 Q2 was available. Finally, for 17 NACE groups (5 at 2-digit level and 12 at 3-digit level) an estimation period from 1980 Q4 to 1988 Q2 was available.

In the search for a causal relationship between output and employment, it would have been satisfying to include the costs of other factors, i.e., capital, energy and materials. However, given that a number of papers (i.e., Flynn and Honohan (1984) and Ruane and John (1984)) have concentrated themselves solely on constructing cost of capital indices for the aggregate, it would have been a formidable task to construct appropriate indices for each individual sector. Also, given the severe limitations on degrees of freedom, it is not really feasible to include other variables. For this reason, a time trend is included in all regressions in an effort to pick up exogenous deterministic influences on the dependent variable other than those explicitly included.

V ESTIMATION AND RESULTS

Before an interpretation is placed on the results yielded from the Granger-Causality tests a number of caveats must be borne in mind. It was mentioned earlier that since a VAR is essentially an unrestricted reduced form of some underlying restricted structural model, no prior expectation can be placed on the signs of some of the coefficients. The lagged own dependent variable in a VAR implies an adjustment process toward some ideal level (i.e., stationarity). However, if the ideal is itself a function of time, it implies that the response of the actual towards the desired may not be proportionate. The inclusion of the time trend and the seasonals in the present study is expected to capture the exogenous influences on the dependent variable other than those explicitly included. If the trend and seasonals successfully capture the exogenous influences and if the best forecasts of the dependent variable are derived from its own past, then the Granger-Causality tests are unlikely to reveal any causality as the effect of exogenous influences is already contained in the past history of the dependent variable. However, since the Granger-Causality F-tests are based on asymtotic theory and since the available sample sizes are relatively small, the results should be seen to be tentative at this stage.

For the aggregate series, a lag length of 1 was chosen by the likelihood ratio test and three of the four information criterion. The summary statistics of this estimated VAR system are presented in Table 1 below.

First inspection of the VAR system reveals significant serial correlation in the residuals produced by the employment equation. This indicates that the employment equation may be misspecified, which may be rectified by estimating a system with a longer lag length. Using Box-Jenkins (1970) techniques for identifying the univariate employment process and the notation ARIMA (p,d,s,q,) where p denotes AR lags, d denotes differencing, s denotes seasonal differencing and q denotes MA lags an ARIMA (4,1,1,0) process was identified. This suggests that information from the past of employment may be suppressed in the employment equation. To successfully remove the serial correlation from the employment equation requires specifying a VAR of lag-length 4.

Table 1: *The Summary Statistics of Aggregate (lag 1) VAR*[+]

Dependent Variable	$\bar{R}^2$	Q-Stat	*Output* F-Stat	*Output* Sum	*Employment* F-Stat	*Employment* Sum	*Hours* F-Stat	*Hours* Sum	*Wages* F-Stat	*Wages* Sum
Output	0.979	30.414	11.906	0.490	0.375	-0.056	5.922	1.209	0.068	-0.052
		(0.084)	(0.001)**	(3.450)	(0.543)	(-0.613)	(0.019)**	(2.436)	(0.796)	(-0.261)
Employment	0.994	65.767	0.269	0.015	2752.3	0.970	14.741	0.384	0.639	0.032
		(0.000)	(0.606)	(0.519)	(0.000)**	(52.46)	(0.000)**	(3.84)	(0.428)	(0.799)
Hours	0.876	18.046	0.390	0.016	10.683	-0.056	79.102	0.820	0.759	-0.032
		(0.646)	(0.536)	(0.625)	(0.002)**	(-3.268)	(0.000)**	(8.894)	(0.388)	(-0.871)
Wages	0.988	21.329	0.274	-0.038	0.254	-0.024	0.024	0.040	44.578	0.684
		(0.439)	(0.603)	(-0.524)	(0.617)	(-0.504)	(0.878)	(0.154)	(0.000)**	(6.677)

+Significance levels and t-ratios for the sum of coefficients are in parentheses. One asterisk denotes statistical significance at the 10 per cent level while two denote significance at the 5 per cent level.

Table 2: *The Summary Statistics of Aggregate (lag 4) VAR*[+]

Dependent Variable	$\bar{R}^2$	Q-Stat	*Output* F-Stat	*Output* Sum	*Employment* F-Stat	*Employment* Sum	*Hours* F-Stat	*Hours* Sum	*Wages* F-Stat	*Wages* Sum
Output	0.974	28.389	3.376	0.537	0.327	-0.027	1.159	1.406	0.498	0.003
		(0.129)	(0.022)**	(0.016)	0.858)	(-0.195)	(0.350)	(1.224)	(0.737)	(0.011)
Employment	0.994	23.407	1.437	0.035	364.3	0.984	0.942	0.341	0.315	0.052
		(0.323)	(0.248)	(0.674)	(0.000)**	(36.68)	(0.454)	(1.524)	(0.865)	(0.842)
Hours	0.908	16.201	0.792	0.024	4.345	-0.079	5.445	0.739	2.605	0.013
		(0.758)	(0.541)	(0.565)	(0.007)**	(-3.648)	(0.002)**	(4.111)	(0.057)*	(0.273)
Wages	0.989	39.550	1.116	0.102	1.593	-0.128	0.318	-0.580	7.426	0.428
		(0.008)	(0.369)	(0.816)	(0.204)	(-1.978)	(0.864)	(-1.077)	(0.000)**	(2.963)

[+]Significance levels and t-ratios for the sum of coefficients are in parentheses. One asterisk denotes statistical significance at the 10 per cent level while two denote significance at the 5 per cent level.

The summary statistics of this estimated VAR system are presented in Table 2 below.

In terms of system serial correlation in the residuals the VAR of lag-length 4 is clearly superior. There are differences between the causality results in the two systems indicating how causality results are sensitive to the choice of lag-structure. However, because of the serial correlation in the employment equation the observed causal relationship between hours and employment may be spurious. One regrettable feature of the lag-length 4 specification is the serial correlation in the wages equation. However, because this study is concentrating on the output-employment relationship the priority should be to choose the lag-length which minimises autocorrelation in the employment equation.

The F-Statistics are the tests for causality and they indicate a striking lack of causality between industrial employment and industrial output (at lag-lengths of 1 or 4). Indeed, Table 2 indicates that there is not even an indirect relationship between output and employment through hours worked. The Granger-Causality tests in the output and employment equations suggest that the appropriate representations of aggregate output and employment may be univariate. A second feature of the test results is the difficulty of identifying a causal influence of real wages on output or employment. Real wages have a positive influence on hours worked which is possibly due to an increase in the supply of hours by workers when it becomes more lucrative to do so especially at overtime rates. Finally, a rise in employment will "Granger cause" a decline in the number of hours worked. This is consistent with the theory that hours are used to fill the "gap" when there is an excess demand for labour.

A problem with using aggregated data is that "averaging" over sectors may dilute causal relationships which are in evidence at the disaggregated level. Therefore, it is possible that the VAR of the aggregate data may not be giving a clear picture of behaviour at the disaggregated level. For this reason similar tests were performed for every sector for which data were available at the disaggregated level.[1] Tables 3 and 4 below summarise the significant causality results obtained from these VARs under two headings: Modern Industries as classified by Baker (1988) (which encompass Office and Data processing, Pharmaceuticals, Electrical Engineering Instrument Engineering and Other Foods) and Traditional Industries (which encompass all other sectors at the NACE-3-digit level along with Non-Metallic Minerals and Timber and Wooden Furniture both of which do not have lower sub-groupings).

1. The summary statistics for all of these regressions are available in appendices contained in Fell, J.P.C., 1989, "In Search of a Causal Relationship between Industrial Output and Employment in Ireland", Central Bank of Ireland Technical Paper 5/RT/89, July.

Table 3: *Summary of Significant Causality Results for 5 Modern Industries**

Dependent Variables	Independent Variables: Output	Employment	Hours	Wages
Output	$\frac{3}{5}$: 2(+) 1(−)	$\frac{0}{5}$	$\frac{2}{5}$: 2(+)	$\frac{3}{5}$: 2(−) 1(+)
Employment	$\frac{0}{5}$:	$\frac{4}{5}$: 4(+)	$\frac{1}{5}$: 1(+)	$\frac{0}{5}$
Hours	$\frac{1}{5}$:1(−)	$\frac{2}{5}$: 1(−) 1(+)	$\frac{2}{5}$: 2(+)	$\frac{1}{5}$: 1(+)
Wages	$\frac{0}{5}$	$\frac{0}{5}$	$\frac{0}{5}$	$\frac{4}{5}$: 4(+)

*This table should be read as follows: In 3 out of 5 cases output Granger causes itself, in two cases a rise in output in the first period caused a rise in output in the following period (i.e., positive causality) while in one case a rise in output in the first period caused a decline in the second period.

The disaggregated data reveals the same conclusion as the aggregate data in that there is a striking lack of causality between Industrial Output and Employment. It is perhaps no great surprise that in not one of the Modern Industries is a causal relationship between output and employment identified (i.e., the transfer pricing argument for example). However, only in a small number of

Table 4: *Summary of Significant Causality Results for 25 Traditional Industries*

Dependent Variables	Independent Variables: Output	Employment	Hours	Wages
Output	$\frac{12}{25}$: 12 (+)	$\frac{7}{25}$: 5(+) 2(−)	$\frac{3}{25}$: 2(+) 1(−)	$\frac{2}{25}$: 2(+)
Employment	$\frac{5}{25}$: 5(+)	$\frac{20}{25}$: 20(+)	$\frac{7}{25}$: 5(+) 2(−)	$\frac{5}{25}$: 3(+) 2(−)
Hours	$\frac{4}{25}$: 3(−) 1(+)	$\frac{9}{25}$: 6(−) 3(+)	$\frac{11}{25}$: 10(+) 1(−)	$\frac{7}{25}$: 6(+) 1(−)
Wages	$\frac{4}{25}$: 2(−) 2(+)	$\frac{7}{25}$: 4(−) 3(+)	$\frac{8}{25}$: 7(−) 1(+)	$\frac{23}{25}$: 23(+)

cases in the traditional sector is a positive causal relationship between output and employment revealed. One interesting feature of the Modern sectors is the importance of hours worked. In two cases hours have significant positive causal influence on output with the sum of coefficients (i.e., the elasticities) exceeding unity in both cases. An increase in hours of work leads to an increase in employment and output in one case in the Modern sector (electrical engineering). However, there is no direct or indirect relationship between output and employment in the Modern sector. The Traditional industries reveal some evidence of a causal relationship between output and the labour input but this relationship does not appear uniform over sectors. Indeed, the evidence is disappointingly weak that a causal relationship between output and the labour input exists in the Traditional sector.

An interesting feature of the results is the importance of real wages in the Modern sector. It appears that proportionately more Modern sectors than Traditional sectors find the real wage an important determinant of output. This appears to be paradoxical in that the Modern sectors have a smaller labour input and are thought to have greater capital intensity than the Traditional sectors. The real wage tends to have little influence on employment in the Traditional sector and no influence in the Modern sector. This indicates that the popular argument of rising real wages in the Traditional sector being labelled as a cause of employment decline and output stagnation could be suspect. It appears that the Modern sector finds the real wage more important than does the Traditional. However, as the real wage represents a combination of the output price and the nominal wage, the significant influence the real wage has on output in the Modern sector may be due to the responsiveness of supply to the output price, and not to the nominal wage. None the less it is possible that foreign multinational firms, that account for the bulk of the high technology modern sectors, may base their initial location decisions on the nominal wage prevailing in a particular area.

VI SUMMARY AND CONCLUDING REMARKS

This paper uses the VAR methodology on the industrial output, employment, hours worked and real wages series both at aggregated and disaggregated levels in an effort to determine whether a causal relationship exists between output and employment. In a sense the study is similar to that of Sims (1974) on the US data. However, the results are strikingly different. At the aggregate level there is an absence of a causal relationship between industrial output and employment. The evidence suggests that the appropriate representations of the employment and output series are univariate. To put this another way, it suggests that the best forecasts of output and employment are derived from their own histories. Also it is found that real wages appear to have no causal influence in output or employment determination. However, given the relatively small size of the sample available for this study, these results must be seen to be tentative.

The results yielded at the aggregate level are confirmed at the disaggregated level in that virtually no causal relationship between output and employment is discovered. The results are different between Modern and Traditional sectors in that more evidence of causality both direct and indirect between output and employment is found in Traditional industry. However, real wages (probably through output prices) have greater effect in the Modern industries.

In conclusion, the present paper identifies variables that might be expected to, but do not appear to, have any role in employment or output determination. However, it does find that the negative relationship that has developed between aggregate industrial employment and output is not a causal relationship. Nevertheless, the paper does not identify other variables that may have an important influence on output and employment determination such as energy costs, material costs or capital costs. This appears to be the logical direction for future research into the output-employment relation in the industrial sector.

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